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THE EVOLUTION OF THE OPHTHALMOSCOPE*

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LIKE many other important inventions and discoveries, that of the ophthalmoscope was the result of the completion and co-ordination, by an exceptionally gifted individual, of the work of many previous investigators.

From the very earliest times, the glowing appearance of the eyes of certain animals, when seen in a dim light, must have attracted notice. The phenomenon was referred to by many writers of antiquity, and formed the subject of much vague and fantastic speculation, devoid of any basis of scientific observation, until early in the 19th century.

Méry¹ in the year 1704, having held a cat under water, noticed that he was then able to see the blood-vessels and the colour of the retina. He was probably the first man to see the details of the fundus in the living eye. Five years later (1709), de la Hire² gave a correct explanation of Méry's observation, showing that immersion under water abolished refraction at the surface of the cornea, and thus enabled the fundus details to be seen. For more than a century after this the possibility of

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examining the fundus details in the living eye appears to have been lost sight of, and the phenomenon of the glowing eye engrossed the attention of all students. The glow was supposed to be due to spontaneous development of light within the eye, under the influence of the nervous system, and was thought to become more vivid when the animal was excited. It was not until the year 1810 that it was proved by Prevost³ to be due to reflection of light from the eye, as it was never visible in a room from which light was completely excluded. In the same year Gruithuisen⁴ traced the effect to the operation of the tapetum, and Rudolf⁵ observed that in order to see the glow the observer must look into the eye in a certain direction. Further observations on this subject were published by several authors during the next forty years. Among these the work of Brücke is of most importance. In a paper⁶ published in 1845 he clearly described the conditions under which the glowing reflex becomes visible, and correctly explained the varying colour of this reflex. He described his method of examination as follows: "I took in one hand a lighted candle from which proceeded the only light which illuminated the room, in the other I held an opaque screen of paper or wood, and shutting one eye, placed myself opposite the animal, lying in a corner of the room, so that its head lay in the visual axis of my open eye. The screen and candle were held close to the visual axis in such a way that the screen shielded my eye from the candle."

The blackness of the human pupil was a thing that had hitherto attracted little attention, being usually attributed to complete absorption of the light entering the eye by the pigmented coats. In fact, a full explanation of it does not appear to have been given until Helmholtz gave it in 1851 in his treatise on the ophthalmoscope.

A reflex from the pupil of the human eye had been observed in certain abnormal conditions, but the possibility of seeing such a reflex in the normal human eye was not recognized until the year 1846, when W. Cumming, at that time house surgeon to the London Hospital, published a very notable and suggestive paper⁷ entitled "On a Luminous Appearance of the Human Eye." Cumming showed that it was possible to see light reflected from the fundus in the normal human eye by a method of examination similar to that employed by Brücke in the examination of animals' eyes. He stated the conditions necessary for seeing this luminosity as follows: "(a) That the eye must be at some distance from the source of light, the distance being greater in proportion to the intensity; (b) that the rays of light diffused around the patient (and sometimes around the eye itself) should be excluded; (c) that the observer should occupy a position as near as possible to the direct line between the source of light and the eye examined." He noted the variation in colour and intensity of the reflex with the

movements of the eye, and discussed the source of the reflection, coming to the conclusion that it occurred mainly at the surface of the choroid. It is particularly noteworthy that Cumming regarded the possibility of seeing the fundus reflex not merely as an interesting scientific discovery, but as affording a valuable means of clinical examination, as the following passage from his paper shows: "The establishment of the fact of a similar reflection from the human eye to that from the eyes of animals, appears to be chiefly important in its adoption as a mode of examining the posterior part of the eye. The retina and choroid, hitherto concealed in the living eye, and little opportunity being afforded of examining their condition after life, in consequence of their diseases not terminating fatally, considerable uncertainty has hitherto attended the diseases ascribed to these structures; but the existence of this luminosity, its non-existence, or abnormal appearance may enable us to detect changes in these structures hitherto unknown, or satisfactorily to see those which we only suspected."

In 1847, a year after Cumming, Brücke⁸ described the appearance of luminosity in the normal human eye examined in this way. It appears certain that Brücke made this observation independently, for a few months after the publication of his paper on the subject, having then heard of Cumming's experiments, he published a short addendum⁹ acknowledging the priority of Cumming's observations. Brücke, however, made an even nearer approach to the discovery of the ophthalmoscope, as is shown by the following extract from his paper: "When I had shown this experiment to a few of my friends, Dr. Carl von Erlach said to me that a long time ago he had seen through his spectacles the eyes of one of his friends glow. He had also questioned me about it once, a year before, but we were interrupted and the fact was not mentioned again. He had, however, often seen the appearance, and had noted that while he saw it his spectacles shone (*spiegelten*). He was able immediately to see my eye glow when I stood before him with my back turned towards the lamp, so that I saw the reflected image of the lamp in one of his spectacle lenses."

It was in the year 1847 that the first ophthalmoscope was invented by Charles Babbage, one of the most distinguished of British mathematicians. Unfortunately, no account of this instrument was published until the year 1854, when Wharton Jones¹⁰ in a "Report on the Ophthalmoscope," published in the *Medico-Chirurgical Review*, wrote as follows: "It is but justice that I should here state, however, that seven years ago Mr. Babbage showed me the model of an instrument that he had contrived for the purpose of looking into the interior of the eye. It consisted of a bit of plane mirror, with the silvering scraped off at two or three small spots in the middle, fixed within a tube at such an angle that

the rays of light, falling on it through an opening in the side of the tube, were reflected to the eye to be observed, and to which one end of the tube was directed. The observer looked through the clear spot of the mirror from the other end."

Wharton Jones was a man of high character and great scientific ability, and there is no reason to doubt the accuracy of the above statement, more particularly as he was probably responsible for the failure of Babbage to pursue his investigations. As there is a reference to this subject in Mr. Brudenell Carter's "Text-book of Ophthalmic Surgery," I wrote to him to ask if he could tell me anything more about it. Mr. Brudenell Carter, now in his eighty-ninth year, very kindly replied to my letter, and wrote on April 25, 1917: "I cannot now remember any further detail, except that Wharton Jones . . . committed the monumental folly of condemning the instrument, so that Babbage threw it aside as a toy of which he thought no more."

While to Babbage belongs the distinction of having first invented the ophthalmoscope, and while we may justifiably take pride in the fact that this achievement stands to the credit of one of our countrymen, that does not detract from the honour due to Helmholtz as the man who devised and made known to the world the instrument which revolutionized ophthalmology.

Helmholtz's monograph,¹¹ published in 1851, was a masterly work. He clearly expounded the optical problems to be solved, and showed the necessity of a method of looking into the eye exactly in the direction of the incident light. He explained how this could be achieved by the use of a transparent mirror, and described a really practical instrument for the examination of the fundus details. It consisted essentially of a transparent reflector, composed of three thin plane parallel plates of glass, set at an angle to reflect the greatest possible amount of light into the eye, while on the observer's side of the mirror was a holder for a concave lens to enable the fundus details of the patient's eye to be seen clearly. In addition, this treatise contained exhaustive studies of various points in relation to the instrument, e.g., the advantages of multiple reflecting plates over single, the most advantageous angle of reflection with different numbers of plates, the polarisation of light reflected by multiple plates and consequent diminution of the corneal reflex, the optical principles underlying the formation of the erect image, and the calculation of its magnification. He referred to the possibility of using two convex lenses, in place of a concave lens, for observation of the image, but did not describe the indirect method as we know it. He noted the insensibility of the optic disc. He indicated the possibility of determining the refraction of the eye with his instrument, and, as showing his appreciation of its clinical importance, I quote the following sentence: "In brief, I believe I may

hold the expectation, not to be exaggerated, that all the alterations of the vitreous body and of the retina, which until now have been found in cadavers, will also be recognizable in the living eye, a possibility which appears to give promise of the greatest advances in the hitherto undeveloped pathology of these structures."

There is reason to believe, however, that Helmholtz did not at first fully realize the epoch-making character of his invention. It was von Graefe who first grasped this. Donders¹² in 1886, in the course of an address on the occasion of the presentation to Helmholtz of the Graefe medal of the Heidelberg Ophthalmological Society, referred to this matter as follows: "He (i.e., Helmholtz) never thought, or at least he never said, that the new instrument implied the dawning of a new era for ophthalmology. von Graefe felt it immediately. When he for the first time saw the background of the eye, with its nerve entrance and its blood-vessels, his cheeks reddened, and he called out excitedly, 'Helmholtz has unfolded to us a new world!'"

Helmholtz¹³ in his speech on this occasion, gave the following interesting account of its discovery. "The ophthalmoscope has unfolded itself to me simply out of the necessity of discussing, in my lectures on physiology, the theory of emission of light from the eye. Why does the human eye not glisten under ordinary circumstances, since in its background there is situated a spot—small, indeed, but clear white, that is to say, the end of the optic nerve, which must reflect light in the same way as the most sparkling tapetum of animals' eyes? Why do animals' eyes shine with such remarkable lustre, though they may be only illuminated by a small distant flame? These questions, when once proposed, were not difficult to answer, and now the answer is known to everybody. Once answered they furnished the means of lighting up the eye of another human being and of seeing it plainly." It appears therefore that the discovery of the ophthalmoscope is another example of a result of enormous practical importance following research in pure science, in some degrees comparable to the revolution in medicine and surgery, which began with the study by Pasteur of the crystals of tartaric acid.

Among the chief defects of Helmholtz's ophthalmoscope were inadequacy of illumination, an inconvenient and time-consuming arrangement for changing the lenses, and the fact that owing to the distance between the eyes of patient and observer the field of view of the fundus was small. Nearly all the extremely numerous modifications of the instrument since introduced were designed to overcome to a greater or less degree these various defects.

Improvement in the illumination was secured by the use of a mirror, either with a portion of the coating removed from a small area, or with a perforation in the centre. In 1851, only a few

months after the publication of Helmholtz's treatise, Epkens¹⁴, a Dutch mechanic, constructed an ophthalmoscope with a plane mirror, with the coating removed from an oval area in the centre. Ruete,¹⁵ in 1852, used a perforated concave mirror, and described the indirect method of examination.

An improvement in the method of changing the lenses was very soon devised by Rekoss, an instrument maker of Königsberg, who modified the original Helmholtz instrument by the addition of two superposed rotating metal discs, each containing four concave lenses of different strengths and a clear aperture.

Innumerable patterns of ophthalmoscope have since been designed. Every conceivable form of reflector has been employed—plane, convex and concave mirrors, with the most various curvatures and diameters, combinations of plane and convex mirrors with convex lenses, silvered lenses, totally reflecting prisms, and the cemented surface of a Nicol's prism.

As regards the arrangements for changing the lenses behind the sight hole, we may group the various devices into four classes: (1) holders or clips into which lenses were inserted singly as in Liebreich's small ophthalmoscope, which is the most familiar example of this class; (2) modification of the Rekoss disc—single, double, or triple discs, or one or two discs with a segment of another; (3) one or more narrow plates with rows of lenses arranged to slide up and down behind the sight-hole; (4) the magazine arrangement devised by Couper, which is also employed, in combination with a disc, in the familiar Morton's ophthalmoscope.

The advantage of being able to approach very close to the patient's eye for direct examination, and at the same time looking perpendicularly through the correcting lens, led to the introduction of various forms of tilting or obliquely set mirrors.

For a time binocular ophthalmoscopes enjoyed considerable popularity. The first of these was designed by Giraud-Teulon (1861). It was found in practice that there was little advantage in getting a binocular view of the fundus, and no binocular instrument could be made as simple and convenient to use as a monocular one. Instruments have also been designed to enable two or three observers to examine the fundus simultaneously.

The first electric ophthalmoscope was invented by Dennett, of New York, in 1884. In 1886 Dr. Thomas Reid, of Glasgow, designed an interesting electric ophthalmoscope with a prismatic reflector and a micrometer scale, an image of which was projected on the fundus. This instrument was shown at a meeting of this Society, but never placed on the market. We have the original model on exhibition here to-day. Another early type of British design is Juler's (1886) which we are also able to show. Most of

the recent developments of this type are, of course, familiar to all ophthalmologists.

This brief review of the evolution of the ophthalmoscope is necessarily incomplete. Time will not permit of any description of many interesting types, such as various forms of autophthalmoscope, nor of the recent developments in reflexless ophthalmoscopy, in which Gullstrand's work is pre-eminent.

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A CASE SHOWING THE EVIDENCES OF RAISED INTRACRANIAL PRESSURE IN SUCCESSIVE PREGNANCIES, AND ATTRIBUTED TO EXAGGERATION OF THE ENLARGEMENT OF THE PITUITARY BODY, NORMAL TO PREGNANCY.

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MRS. ANNIE L——, 30 years of age, saw me at the Royal London Ophthalmic Hospital on January 25, 1916, complaining of misty vision, variable, but the left eye was considered to be the worst. For about four months she had experienced double vision and had been having very severe headache for three months. At this date she was five months advanced in pregnancy, and had up to that time suffered from much vomiting, but it was not so bad as it had been. She had suffered from vomiting in two previous pregnancies, but the symptom did not persist so long as it had done on the present occasion. It was found that she had paralysis of the left external rectus, and that the sight of this eye was 6/18, three letters. With the right eye the vision was 6/6: pupils were normal. There was